1982

Depositional Environment Of The Type Section Of The Seward Formation (Lower Pleistocene), Nebraska

William J. Wayne
University of Nebraska-Lincoln

1982. *Transactions of the Nebraska Academy of Sciences,* X:49-55.

DEPOSITIONAL ENVIRONMENT OF THE TYPE SECTION OF THE SEWARD FORMATION (LOWER PLEISTOCENE), NEBRASKA

William J. Wayne

Department of Geology
University of Nebraska-Lincoln
Lincoln, Nebraska 68588

The Seward Formation as originally described was known largely from subsurface data; the authors considered it a fine-grained facies of the Ogallala. It was later correlated with the Elk Creek Till of the Nebraskan glaciation and an outcrop selected in northeastern Seward County as a type section of the unit. Recent research has demonstrated that the Elk Creek Till is much older than the classical Nebraskan tills. The upper part of the exposure designated the type section of the Seward Formation is a massive silt unit that has a thick chernozemic paleosol, and the lower part is laminated silt and clay with a thinner $CaCO_3$-rich paleosol. Land snails collected from a sparsely fossiliferous zone near the base of the massive silt unit represent only five species; 88% are about equally divided between *Pupilla muscorum* and *Gastrocopta armifera,* both long lived and widely distributed taxa that indicate open grassland.

This faunule and the massive, nearly uniform nature of the silt from which it was collected suggest that part of the sediment may have been deposited as loess. Its thick soil profile, which is buried beneath a laminated silt and fine sand that is overlain by Cedar Bluffs Till a short distance away, is well developed. Judged by post-Wisconsinan soil profile development, it probably would have required several times as long to form. The upper part of the Seward Formation at its type section probably correlates with the Elk Creek Till, which was deposited by the earliest ice to reach the area of eastern Nebraska. The basal part of the formation probably is Pliocene. It is likely that not all the silts identified as Seward Formation from well logs and samples have the same origin as these beds at the outcrop of the type section.

† † †

INTRODUCTION

The name Seward Formation was applied by Condra, Reed, and Gordon (1947) to a calcareous gray silt or siltstone that fills some buried bedrock valleys in southeastern Nebraska and which they believed to be an eastward fine-grained facies of the Tertiary Ogallala Formation. They designated no type section, however. Goll (1961:28) used the name "for calcareous silt lying below Nebraska Till and above Cretaceous bedrock" in samples from Seward County test holes; he reported that it "ranges from 16 feet to 198 feet" thick. He also reported carbonaceous material and snail shells in a few samples. In one outcrop in northeastern Seward County (Figs. 1 and 2), Goll (1961:Pl. 2-A) illustrated silt that contains organic matter and that lies sandwiched between Cretaceous rocks and an overlying laminated silty clay. He considered the entire section to be the Fullerton Formation, which had been defined by Lugn (1935:98-103) as an "Aftonian" Silt, but was described later by Reed and Dreeszen (1965:25) as a "periglacial equivalent" of Nebraska Till. Goll (1961:43 and 65) noted that snail shells were present in the

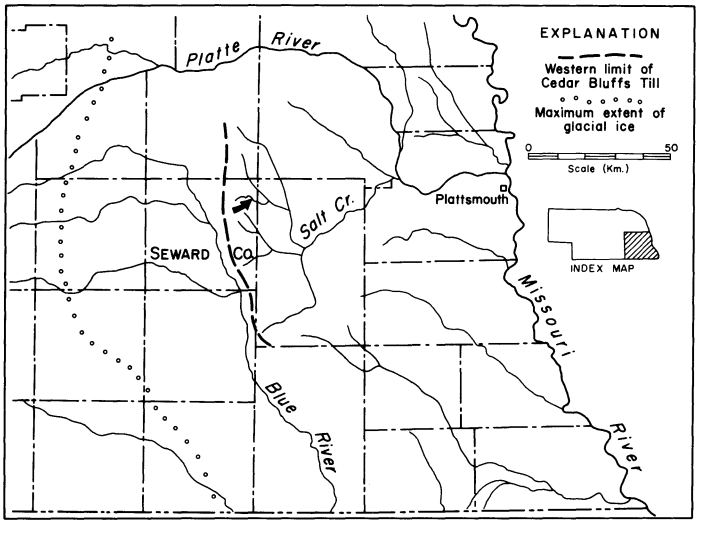

FIGURE 1. Map of southeastern Nebraska showing major drainage lines and glacial boundaries. Arrow points to location of section described. Base from U.S. Geological Survey Map of Nebraska, scale 1:1,000,000.

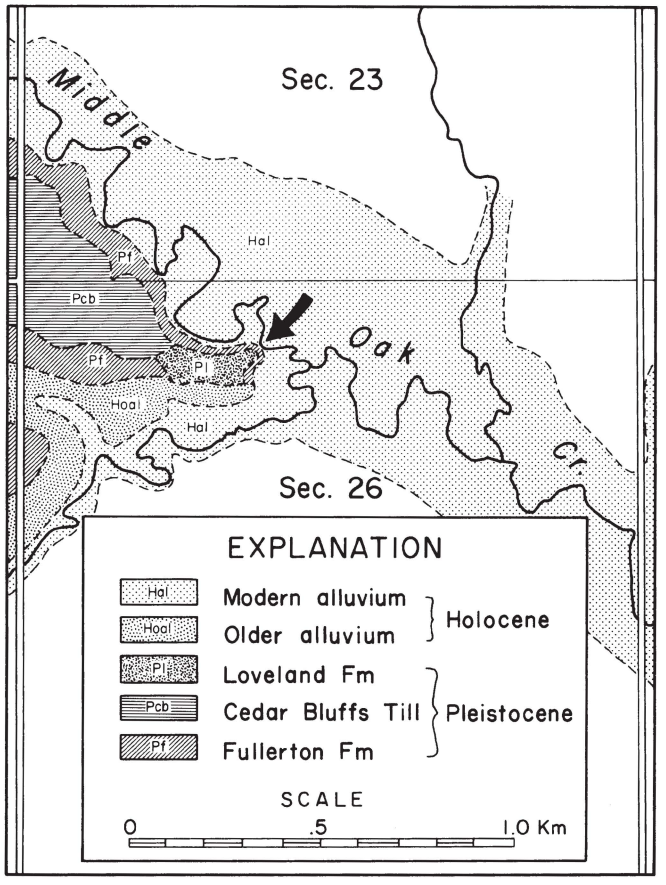

FIGURE 2. Map showing location of section (arrow) and surface geology of adjacent area. Base from U.S. Geological Survey Garland Quadrangle, scale 1:24,000.

lower part of the exposure. Reed and Dreeszen (1965:50), reinterpreting this outcrop in northeastern Seward County, regarded the lower part of it to be Seward Formation and designated it the type section of the unit. They limited the name Fullerton Formation to the sediments that overlie the thick, dark paleosol.

Reed and Dreeszen's type section of the Seward Formation is a stream bank exposure about 7 m high (Table I) and nearly vertical (Fig. 3). At the base is less than 1 m of limonitic sandstone and shale, the top 20 cm of which is cemented with hematite. These rocks are part of the Dakota Formation of Cretaceous age. Two silt and clay units overlie the sandstone and shale. The lower one has discontinuous laminae and is not calcareous, but its upper part contains abundant secondary $CaCO_3$ and probably is part of a buried paleosol. The upper unit is a massive, compact, gray silt bed about 2.0 m thick. The lower part of this bed is calcareous, but the top 1.2 m, in addition to being non-calcareous, is dark gray and displays a blocky texture (Table I). Tubes, probably burrows,

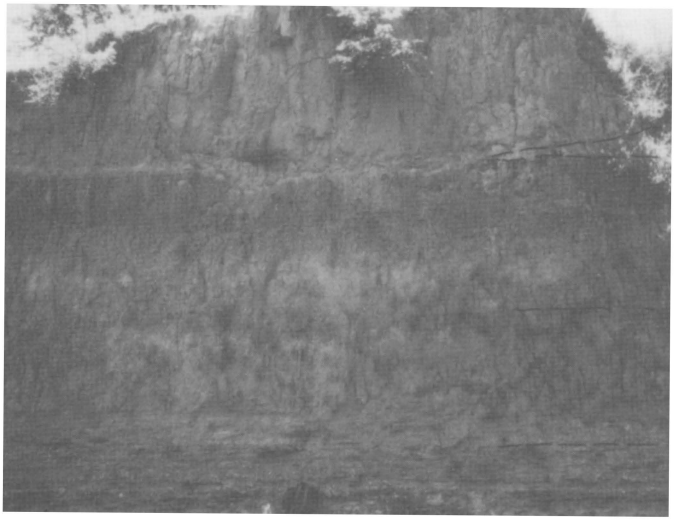

FIGURE 3. Exposure in northeastern Seward County designated by Reed and Dreeszen (1965) as the type section for the Seward Formation. Dashed lines mark the base of the unit, the top of the mid-unit paleosol, the top of the Seward Formation, and the top of the Fullerton Formation, which thickens to the right. The massive and vertically jointed sediment above the Seward and Fullerton formations in this photograph is the Loveland Formation.

filled with this dark-gray sediment extend downward more than 0.5 m below the base of the material. Snail shells are very sparse in a zone about 30 cm thick that is at the base of the upper silt unit.

The exposure was visited to learn more about the beds with organic material and fossils reported to be in it and to collect some of the snails for paleoecologic and stratigraphic interpretation. Unfortunately, the snails are not abundant. Approximately 25 kg of silt mined from the single 20- to 30-cm-thick zone where shells appeared on the outcrop yielded only 156 identifiable snails and two small bone fragments (Table II).

PALEONTOLOGY

Five taxa, all land snails, are represented, two of which, *Gastrocopta armifera* (Say) and *Pupilla muscorum* (Linné), make up 88% of the total faunule (Table II). Both of these pupillid species are extant and are widely distributed in both time and space. They do, however, permit interpretation of the depositional environment of the sediments that enclose them.

Pupilla muscorum (Linné) (Fig. 4a) is holarctic; it is found from northern Europe and Asia to North Africa in the eastern hemisphere and from Hudson Bay and Alaska through the Rocky Mountains to Socorro, New Mexico, and eastward to

TABLE I. Stream bluff in Seward County, Nebraska, in the center NE¼ NW¼ Sec. 26, T. 12 N., R. 4 E., altitude of base of section (from Garland Quadrangle) 398 m (1,310 ft).

Description	Soil Horizons	Thickness
LOVELAND ALLUVIUM (exposed in ravine along valley wall)		
Loam, dark brown (7.5YR3/2), base gradual, smooth	A	0–45 cm
Loam, clayey, brown (7.5YR4/4), medium prismatic, cutans indistinct, base gradual, wavy	B2t	45–85 cm
Loam, sandy, dark-yellowish brown (10YR4/4), vaguely bedded to massive, contains scattered small voids	C	5.3 m
Sand, gravelly, base uneven but sharp		0.5 m
FULLERTON FORMATION		
Sand, fine, silty, loose, light-brownish gray (2.5Y6/2), calcareous, micro-cross-laminated; top eroded		9.0 m
Silt, clayey, light gray (2.5Y7/2) laminated, with one bed 26–30 cm above the base that has very fine, dark laminae, blocky fracture, top gradational and base abrupt, not calcareous; thins and is cut out on east side of main exposure		0.60 m
SEWARD FORMATION		
Silt, clayey, dark gray (5YR4/1), blocky, not calcareous	IIAb	0.20 m
Silt, clayey, brown (7.5YR5/2), blocky, not calcareous	IIB2tb	0.60 m
Silt, clayey, grayish brown (2.5Y5/2), massive-to-medium bedded, not calcareous	IIB3b	0.40 m
Silt, grayish brown (10YR5/2), looks massive, but has subparallel joints or bedding planes 5 to 15 cm apart marked by limonitic borders 5 mm thick; calcareous, but with non-calcareous, gray (10YR5/1), oval burrow fillings, very sparse snail shells in lower part; top and base gradual	IIC	0.90 m
Silt, clayey, gray (10YR5/1), calcareous, massive, sparse small nodules of chalky $CaCO_3$ near base; a few diffuse small, black masses near top	IIIAb	0.45 m
Silt, clayey, light-brownish gray (2.5Y6/2) mottled with white (10YR10/1), highly calcareous; a somewhat diffuse zone 7–10 cm thick near top is brown (7.5YR5/4), base abrupt, top gradual	IIIBCcab	0.35 m
Silt, clayey, yellowish brown (10YR5/5), calcareous, not laminated, sparse very pale brown (10YR7/3) chalky concretions; 10-cm-diameter tubular burrow in middle filled with brown (10YR5/3) silty clay	IIICcab	0.40–0.50 m
Clay, light gray (10YR6/1), laminated with silty clay, yellowish brown (10YR5/8) silty clay laminae 2–15 mm thick; not calcareous, but containing nodules with $CaCO_3$ cement	IIIC	0.30 m
Clay, light gray (10YR6/1), with brown (7.5YR4/4) mottles, laminated, not calcareous, moderately indurated when dry; band of indurated limonitic (7.5YR4/6) sandy clay 10 cm thick with bands of dark gray (7.5YR3/0), 10–20 cm above the base		0.80 m
DAKOTA FORMATION		
Clay, hematitic, dusky red (10R3/3), indurated, breaks readily into squarish blocks	IV plinthite b	0.20 m
Sand, slightly clayey, light-olive brown (2.5Y5/5) loose		0.20 m
Covered to stream level		0.50 m

the Great Lakes States in North America. Taylor (1966:86 and 91) reported it in sediments of Late Blancan (Early Pleistocene) age in Jackson Hole, Wyoming, and it is known from Pleistocene sediments identified as "Kansan" in age and younger in Kansas (Leonard, 1950 and 1952), Illinois (Leonard, Frye, and Johnson, 1971), and in Indiana (Wayne, 1963). It lives in open grasslands that are relatively humid and cool.

Gastrocopta armifera (Say) (Fig. 4b) is a common snail in semi-exposed regions. It is a species of grassy terrain, the forest-prairie ecotone, and rock exposures where lime is abundant east of the Rocky Mountains from Alberta to Ontario, southward to Florida and New Mexico (LaRocque, 1970:717-719). It is common in loesses of Wisconsinan age from the Ohio Valley to the Great Plains. Taylor (1966)

TABLE II. Mollusk fossils collected from type section of Seward Formation.

Species	No.	%	University of Nebraska State Museum Cat. No.
Gastrocopta armifera (Say)	63	40.4	UNSM 17757
Punctum cf. *minutissimum* (Lea)	7	4.5	UNSM 17758
Pupilla muscorum (Linné)	74	47.4	UNSM 17759
Succinea cf. *exile* Leonard	11	7.1	UNSM 17760
Vallonia cf. *puchella* (Müller)	1	0.6	UNSM 17761
Total	156	100.0	

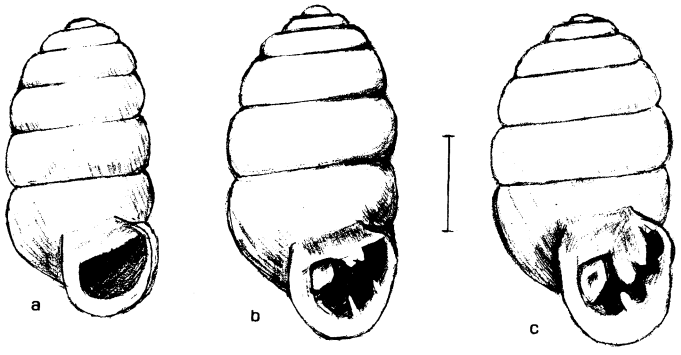

FIGURE 4. a-b. Drawings of snail shells from the type section of the Seward Formation. **a.** *Pupilla muscorum* (Linné). **b.** *Gastrocopta armifera* (Say). **c.** *Gastrocopta proarmifera* Leonard, collected from aggradational proglacial flood plain sediments associated with the Cedar Bluffs glacial advance that are exposed along Middle Creek, 10 km to the south (*see* Wayne, 1981). Projection between b and c represents 1 mm and applies equally to a-c.

included it as a Blancan faunal element from its occurrence in the Rexroad Formation of Kansas, which is either Early Pleistocene or Late Pliocene in age.

Many of the sediments identified as "Yarmouth" or "Kansan" in age in the midcontinent and in Indiana contain a form that has much more massive apertural lamellae and folds referred to *G. proarmifera* Leonard by Leonard (1950) and by Wayne (1967 and 1981). Hubricht (1972) placed *G. proarmifera* in synonomy with *G. ruidoensis* (Cockerell), and Taylor (*in* Hibbard and Taylor, 1960: 124–126) considered both forms to be variants of *G. armifera.* The form in the sediments discussed here is identical to the one living today in both southern Indiana and Nebraska and collected from the Peoria Loess of these areas. It can be distinguished readily from *G. proarmifera* by its smaller lamellae (Figs. 4b and 4c).

The remaining three molluscan taxa constitute only 12% of the specimens collected and provide little additional information about the bed. A small succineid, with 11 individuals, is the most abundant of the group. Unfortunately, the small, fossil succineids are difficult to use for either stratigraphic or ecologic purposes because several species may have virtually identical shells. The two unbroken and reasonably mature specimens in this faunule resemble the form Wayne (1963: 60, Fig. 8a) illustrated and called *S. gelida* var., and which Leonard (1972) later named *S. exile.* Wayne collected this succineid from three fossiliferous beds in the Jessup Formation of Indiana, the youngest of which is the silt that underlies the basal till of Illinoian age. Leonard's type specimens were collected from the Petersburg Silt, which has the same stratigraphic relationship (Willman and Frye, 1970:52–53). Other specimens came from silts correlated with the "Kansan" Stage in both Illinois and Indiana. Most of the small succineids inhabit open, moist areas, and it is likely that this one did too.

The seven specimens of a tiny helicoid snail are mostly immature or broken and so the identification, *Punctum* cf. *minutissimum,* can be only tentative. A single shell with the body-whorl sculpture of *Vallonia pulchella,* but with the aperture broken, likewise provides no useful data.

The remains of vertebrates collected were identified by R. George Corner, paleontologist at the University of Nebraska State Museum, as a skull fragment and a broken limb bone, both probably mammalian. They contribute nothing to either the stratigraphic or ecologic interpretation of the enclosing sediments.

DEPOSITIONAL ENVIRONMENTS

The sediments in the type section of the Seward Formation consist of two units, each of which has undergone considerable weathering. The lower part of the exposure is a slightly indurated silty clay that is not calcareous and that contains discontinuous laminae of clayey silt. Such a sediment sequence could have been deposited along the flood plain of a small stream. The top 80 cm are the solum of a buried soil profile that must have developed under conditions considerably more arid than those today. The 35-cm-thick chalky zone has the field characteristics of a pedogenic carbonate accumulation. The brown band in the upper part of it may represent a thin B2t horizon that has become nearly masked by the accumulation of soil carbonate. The thickness of the BCca

zone, especially in view of the compaction resulting from burial, suggests that considerable time was involved in its development.

The carbonate-rich paleosol is overlain by the only fossiliferous bed in the section, the basal 30 cm of a massive calcareous silt that makes up the upper half of the Seward Formation in this exposure (Table I). The presence of five species of land snails and two small vertebrate bones along with the apparent absence of bedding suggest that this sediment was deposited in a non-aqueous environment. It is calcareous and it has a massiveness commonly associated with wind-laid silts. The snail faunule in the silt suggests that temperatures were somewhat cooler than those today. Such conditions probably would have accompanied the Early Pleistocene glaciations in this area. *Pupilla muscorum* is a northern species that was common near the ice margin in Illinois and Indiana during the Wisconsinan glaciation. *Succinea exile* is known only from proglacial loessal silts, so it surely lived in cool environments too, but its distribution is not known. *Gastrocopta armifera* tolerates a wide range of conditions. The two extant taxa are open country species, and the extinct one is known only from similar assemblages. The vegetation probably was dominated by prairie grasses at the time the silt accumulated; the temperature and humidity could have been similar to those in west-central Minnesota today, which is within the present range of the two abundant and extant species in this faunule. Sedimentologic and paleontologic data suggest that the silt would more likely be a loess than a flood plain overbank sediment.

If the upper unit in the type section of the Seward Formation should be a loess, a source for the silt would be needed. When glacial ice blocked the northeastward-flowing rivers of the northern Great Plains, they were diverted southward beyond its margin (Stanley and Wayne, 1972). The large and undoubtedly braided river that resulted spread much of the gravel and sand that covers the region a short distance west of Seward. Such a river would have provided a readily available source of silt to be blown eastward where it would accumulate on the upland, as did flood plains of the Missouri and Mississippi during the Wisconsinan glaciation.

The buried soil profile of this silt unit is dark brownish-gray, and the 60-cm-thick former "B" horizon has a blocky structure. The sediments immediately above the paleosol are finely laminated and grade upward into cross-bedded fine sand and coarse silt (Table I) that is overlain by alluvium with a Sangamon weathering profile. The solum of the buried soil beneath them has been compressed and undoubtedly has undergone additional diagenetic changes. Nevertheless, its thickness, color, and B-horizon characteristics suggest that it was exposed to pedogenic processes for a relatively long time (considerably longer than 12,000 to 15,000 or so years that the Peoria Loess has been exposed), and that the dominant vegetation during the period before burial was prairie grasses.

The laminated non-calcareous clayey silt, called Fullerton by Reed and Dreeszen (1965), that overlies the paleosol developed at the top of the Seward Formation grades upward into cross-bedded silt and fine sand. These sediments resemble silts deposited elsewhere in Seward and Lancaster counties in proglacial lakes that existed during the advance of the last glacial ice to cover the region (Stanley, 1974) and now are discontinuously covered with Cedar Bluffs Till. The substitute type section of the Fullerton Formation in northwestern Lancaster County (Reed and Dreeszen, 1965:26 and 50) is similar. Although no till is present in the type section of the Seward, a short distance away in gullies along the upland ridge to the west (Fig. 2) till regarded as the Cedar Bluffs overlies these stratified silts. Lower, at the location of the Seward Formation outcrop, the Fullerton Formation fine sands and silts are overlain unconformably by alluvial sediments (Table I) that have a Geary soil profile (Quandt, 1974).

CORRELATION

Condra, Reed, and Gordon (1947 and 1950) believed the silt they named the Seward Formation to be an eastward and finer grained facies of the Ogallala Formation; they stated that it is as much as 60 m (200 ft) thick. Reed and Dreeszen (1965) disagreed with the original interpretation. They said that the Seward Formation is the "periglacial equivalent of the Elk Creek Till," and that it was "deposited as the Elk Creek ice sheet retreated."

In the part of this exposure that Reed and Dreeszen (1965) designated the type section of the Seward Formation, two different sedimentary units are present. The lower unit is laminated and non-calcareous; the soil profile developed on it could be called an Aridisol. The upper unit is a non-laminated silt that contains a few fossil snails near its base; the buried paleosol formed on it is a Mollisol. Both profiles were maturely developed prior to burial and, under the conditions that may be reasonably assumed from modern analogues, each probably required at least 10^5 and possibly even 10^6 yr for development. The upper unit of the Seward Formation underlies fine sand and silt of the Fullerton Formation, which was deposited in advance of the ice that left the Cedar Bluffs Till.

Classically, the Early Pleistocene glaciations in North America have been two, the Nebraskan and the Kansan. Boellstorff (1976, 1978a, and 1978b), however, has found that the Early to Mid-Pleistocene deposits of Nebraska and western Iowa include seven tills. He reported a paleosol of some consequence to be present on each of the tills and that fission-track dates of volcanic ash lenses associated with the tills show that all the tills in Nebraska are greater in age than

700,000 yr. The type Nebraskan Till is one of a group that was deposited between 1.2 and 0.7 m.y.B.P. The type Kansan Till in Iowa is still younger; it overlies a 0.6-million-year-old ash.

The oldest and lowest of these tills, which contains a higher proportion of locally derived pebbles than the younger tills, was deposited about 2.5 m.y.B.P. (Boellstorff, 1978b). This till, the Elk Creek, has been called Nebraskan (Reed and Dreeszen, 1965:23-24), although it is clearly much older than the tills of the type Nebraskan and of the classical Nebraskan section at Afton, Iowa. At this time, the terms "Nebraskan" and "Kansan" no longer have any meaning with respect to the tills Boellstorff (1978b) has been able to define. The tills do seem to fall into three groups, however, and Boellstorff (1978b:45) suggested using informal chronozones until stage concepts can be reorganized.

In the City Wide Quarry near Plattsmouth, the Elk Creek Till has at its top a buried paleosol of somewhat comparable thickness, development, and character to the one that caps the Seward Formation in its type section. This, along with the stratigraphic position of the Seward beneath the Fullerton Formation, which probably was deposited in front of and was overridden by the ice that deposited the Cedar Bluffs Till, and the cool climate faunule in it, suggests that the upper part of the type section of the Seward Formation might reasonably be correlated with the Elk Creek Till. Boellstorff placed the Elk Creek Till in the oldest of the three chronozones he suggested for the Pleistocene of eastern Nebraska, and the Cedar Bluffs Till is one of five tills in the second chronozone.

The lower unit in the Seward Formation type section, though, is very different. Non-calcareous, laminated, slightly indurated, and with an Aridisol soil profile that formed on it before it was buried, it seems likely that it was deposited during Pliocene time and was weathered while the climatic conditions that produced the thick carbonate-rich soil profile on the Ogallala Formation in western Nebraska prevailed.

Condra, Reed, and Gordon defined the Seward Formation from subsurface data and referred to it as a unit of considerably greater thickness than is exposed in this section. Such thick silt units probably were deposited in the valleys of eastward-flowing rivers blocked by glacial ice. Thus, most of the Seward Formation probably was deposited in a different sedimentary environment from the thin units exposed in the surface type section of the formation.

REFERENCES

Boellstorff, J. 1976. The succession of Late Cenozoic volcanic ashes in the Great Plains. *Kansas Geological Survey, Guidebook Series,* 1:37-71.

_____. 1978a. North American Pleistocene stages reconsidered in light of probable Pliocene-Pleistocene continental glaciation. *Science,* 202:305-307.

_____. 1978b. Chronology of some Late Cenozoic deposits from the central United States and the ice ages. *Transactions of the Nebraska Academy of Sciences,* 6:35-49.

Condra, G. E., E. C. Reed, and E. D. Gordon. 1947. Correlation of the Pleistocene deposits of Nebraska. *Bulletin of the Nebraska Geological Survey,* 15:1-71.

_____, _____, and _____. 1950. Correlation of the Pleistocene deposits of Nebraska. *Bulletin of the Nebraska Geological Survey,* 15A:1-74.

Goll, C. L. 1961. The geology of Seward County, Nebraska. Master of Science thesis, University of Nebraska: 111p.

Hibbard, C. W., and D. W. Taylor. 1960. Two Late Pleistocene faunas from southwestern Kansas. *Contributions from the Museum of Paleontology, University of Michigan,* 16(1):1-223.

Hubricht, L. 1972. *Gastrocopta armifera* (Say). *Nautilus,* 85(3):73-78.

LaRocque, A. 1970. Pleistocene mollusca of Ohio. *Bulletin of the Ohio Geological Survey,* 62:555-800.

Leonard, A. B. 1950. A Yarmouthian molluscan fauna in the midcontinent region of the United States. *University of Kansas Paleontological Contributions, No. 8, Mollusca,* Article 3:1-48.

_____. 1952. Illinoian and Wisconsinan molluscan faunas in Kansas. *University of Kansas Paleontological Contributions, No. 9, Mollusca,* Article 4:1-38.

_____. 1972. New gastropods from the Pleistocene of Illinois. *Nautilus,* 85(3):78-84.

_____, J. C. Frye, and W. H. Johnson. 1971. Illinoian and Kansan molluscan faunas of Illinois. *Circular of the Illinois State Geological Survey,* 461:1-23.

Lugn, A. L. 1935. The Pleistocene of Nebraska. *Bulletin of the Nebraska Geological Survey,* 10:1-223.

Quandt, L. A. 1974. *Soil survey of Seward County, Nebraska.* Washington, D.C., United States Department of Agriculture, Soil Conservation Service: 85p.

Reed, E. C., and V. H. Dreeszen. 1965. Revision of the classification of the Pleistocene deposits of Nebraska. *Bulletin of the Nebraska Geological Survey,* 23:1-65.

Stanley, K. O. 1974. Morphology and hydraulic significance of climbing ripples with superimposed micro-ripple-drift cross-lamination in Lower Quaternary lake silts, Nebraska. *Journal of Sedimentary Petrology,* 44(2): 472-483.

_____, and W. J. Wayne. 1972. Epeirogenic and climatic controls of Early Pleistocene fluvial sediment dispersal in Nebraska. *Bulletin of the Geological Society of America,* 83:3675-3690.

Taylor, D. W. 1966. Summary of North American Blancan nonmarine mollusks. *Malacologia,* 4(1):1-172.

Wayne, W. J. 1963. Pleistocene formations in Indiana. *Bulletin of the Indiana Department of Conservation, Geological Survey,* 25:1-85.

_____. 1967. Periglacial features and climatic gradient in Illinois, Indiana, and western Ohio, east-central United States. *In* E. J. Cushing and H. E. Wright, Jr. (eds.), *Quaternary Paleoecology.* New Haven, Connecticut, Yale University Press: 393-414.

_____. 1981. Kansan periglacial environment, east-central Nebraska. *American Journal of Science,* 281(4):375-389.

Willman, H. B., and J. C. Frye. 1970. Pleistocene stratigraphy of Illinois. *Bulletin of the Illinois State Geological Survey,* 94:1-204.